DECLARATION OF WADE THOMAS CATHEY UNDER 37 CFR §1.132

Dear Sir:

I, Wade Thomas Cathey, declare that:

1. I currently reside at 360 Alpine Way, Boulder, Colorado 80304.

2. I am an inventor named in U.S. patent application Serial No. 09/070,969, filed on 1 May, 1998 ("the '969 application"), and a continuation application thereof, Serial No. 10/758,740, filed 16 January 2004 ("the '740 application"), both applications entitled Extended Depth of Field Optical Systems.

3. I have obtained the following university degrees: B.S. (Electrical engineering, University of South Carolina, 1959); M.S. (Electrical engineering, University of South Carolina, 1961); Ph.D. (Electrical engineering, Yale University, 1963). From 1962 to 1968, I was Group Scientist in the Laser and Electro-Optics Department, Autonetics Research Center, Rockwell International Corp., Anaheim, California, where I supervised and conducted research in pattern recognition, coherent optical information processing, holography, propagation of coherent waves through the atmosphere, imaging through random media, and laser arrays. From 1968 to 1977, I was Associate Professor and then Professor of Electrical Engineering, University of Colorado, where I taught courses in optics, communications, field theory, and logic. I also performed and direct research in holography, spatial filtering, coherent optics, imaging systems and sampling theory. From 1983 to 1987 I also was the Director, of an NSF Engineering Research Center for Optoelectronic Computing Systems. From 1997 to 2003, I was a Research Professor, Electrical and Computer Engineering, University of Colorado, doing research on hybrid optical and signal processing imaging systems. I am a fellow of the Optical Society of America, the Institute of Electrical and Electronics Engineers, Fellow, and the SPIE.

4. I am a founder and currently President of CDM Optics, Inc. of Boulder, Colorado, the assignee of the '969 and '740 applications.

5. I am familiar with the official Office Actions dated 9 November, 2004 in the '969 application and dated 5 November, 2004 in the '740 application, and with the prior art references cited therein. I am for example familiar with U.S. Patent No. 4,804,249 issued to Reynolds et al. ("Reynolds").

6. An optical transfer function ("OTF") characterizes an optical system by defining the transfer function from an object point to an image. A cross-section of the OTF at the point image provides the commonly-known "point spread function." The OTF thus provides phase and blur information related to imaging capability of the optical imaging system. The convolution of the OTF with a mathematical construct of the object provides a theoretical image, which predicts the image quality of an actual image through the optical imaging system. The modulus of the OTF is called the modulation transfer function, which does not include phase information. This definition means that an OTF of a system depends on more than the numerical aperture of the lens of the system; for example the OTF also depends upon object distance, i.e., that distance between an object and the optical imaging system.

7. If an optical element is "transparent", this does not mean that there is no absorption by, or scattering or reflection from the optical element. Rather, a transparent optical element means

that the amplitude of light is generally the same after passing through the optical element (losing only a small percentage to absorption, scattering, reflection).

8. It is understood that spatial frequencies are an inherent aspect of an image, higher spatial frequencies within an image providing greater information content or clarity. The range of these spatial frequencies is defined by the optical bandpass of optics of an optical imaging system forming the image; this range being determined by the limiting aperture of the optical imaging system. An image recording device can only detect a range of spatial frequencies that passes through the optical bandpass, the highest detectable spatial frequency corresponding to the smallest angular spacing of adjacent detecting elements of the image recording device. Accordingly, if an image recording device captures an image, and if one desires to image process data from the image recording device, then this can be done only within the range of spatial frequencies that are in fact detectable by the image recording device. Therefore, in claims of the '740 and '969 applications, an optical transfer function contains no zeroes within a range of spatial frequencies detected by an image recording device.

9. Each of FIG. 10 through FIG. 15 in the '740 and '969 applications, as filed, show a range of spatial frequencies in which the OTF does not contain zeroes. This range corresponds to the optical bandpass of the optical imaging system centered about a spatial frequency of zero. FIG. 15 is for example shown below. Note that a large frequency range exists, centered about zero, in which an OTF of an optical system does not have zeroes. With this OTF, a detector can be chosen such that there are no zeros in an optical transfer function over detected spatial frequencies of the optical image.

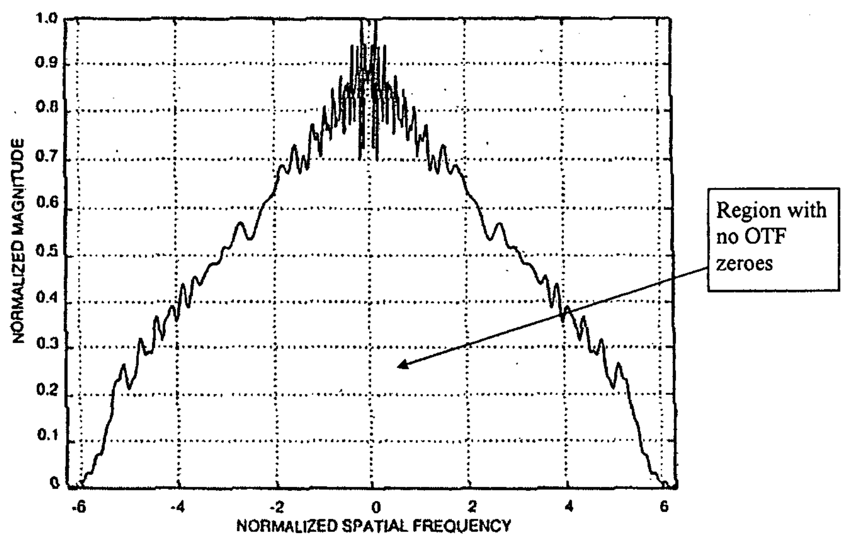

Fig. 15

10. A variable or an equation may be normalized, and that normalization may make a variable unitless. Thus the normalization of the equation that appears at page 16, line 3 in the specification of the '740 application, as filed, makes it clear that the spatial parameter x and spatial frequency parameter u are unitless.

11. Optical materials having variations in opacity, thickness, diffractive properties and/or index of refraction are known in the art of optics. It is well known, for example, that the optical element commonly known as a "zone plate" consists of a series of concentric opaque rings (i.e., variations in opaqueness) acting together to focus light. Common plano convex lenses use variations in thickness to form focused images. Holographic Optical Elements (HOEs) use diffractive structures (i.e., variations in diffractive properties) to focus images, while variations in index of refraction is demonstrated in the "Grin lens," which uses spatial variations of index of refraction to form focused images."

12. Reynolds discloses an optical filter with transparent, discrete steps, each step having a thickness that differs from all other steps by at least the coherence length of transmitted radiation. As a person skilled in the field of optics appreciates, the size of the Reynolds' lateral step determines the cut-off frequency of the optical system, thereby reducing the useful optical bandpass of the optical system as determined by the system aperture. Further, Reynolds' optical filter results in a dramatic reduction in the spatial frequency passband of the optical system, and these spatial frequencies can not be recovered by post processing.

13. Claims of the '740 and '969 applications involve modifying phase, such as by an optical phase mask. Modifying phase as described in the applications does not reduce the usable and desirable frequency range of the optical bandpass as defined by the system optical aperture. Rather, these applications extend the depth of field for which the OTF has no zeros so that a crisper image may be obtained as compared to an image without modifying phase in this way. On the other hand, the discrete steps of Reynolds in fact destroy the useful frequency range obtainable through the optical bandpass because the images cannot be coherently combined.

14. Further, the claims of the '969 application utilize post-processing, (a) to "render an in-focus electronic image" (as in claims 75, 87 and 88) or (b) for "reversing an alteration in an image induced by phase alteration" (as in claims 89 and 94) or (c) for "reversing the step of optically altering by electronically processing a digital representation of the image to increase the optical depth of field" (as in claim 99). Utilizing the optical filter described by Reynolds would thwart the actions required by these claims; that is, "an in-focus electronic image" cannot be rendered, "an alteration in an image induced by phase alteration" cannot be reversed, and "the step of optically altering" cannot be reversed, because of the permanent reduction in the passband of the optical system done by Reynolds' optical filter. Reynolds purposefully restricts the frequency range to make a low-pass filter that eliminates aliasing in the final image, thus reducing overall image clarity.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that the statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the Application or any patent issued thereon.

Respectfully submitted,

Wade Thomas Cathey

Dated: 6 May 05